A COMBINED APPROACH TO DETECT URBAN FEATURES FROM MULTI-SPECTRAL AND RADAR DATA

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1. INTRODUCTION

Urban sprawl has become an increasingly topic in order to protect environment and reduce alteration of urban development on natural ecosystems. Urbanization has an impact on several processes like hydrology or climatology [1], [2], and competes with agricultural activities. The periurban environment represents a transitional space between urban and rural regions. This complex landscape is characterized by different types of land cover and land use: houses, industrial buildings, collective buildings, farms, roads, natural vegetation, agricultural fields, etc … Satellite imagery represents an essential source of information to analyze this urban fabric. Many studies have shown the possibilities using classification algorithms to identify urban structure and land cover mode. Multi-spectral data are mainly used from Landsat and SPOT satellites with different spatial resolutions depending of local or regional study scale. However, limits to distinguish all surface types and confusion between different cover modes are established [3], [4], [5]. Less studies use radar data to characterize urban fabric but the SAR system presents some advantages like operated at day or night, with the presence of clouds or fog but it is dependent on the radar frequency, polarization and viewing geometry and limited by its relative coarse spatial resolution [6], [7].

The main objective of this paper is to detect objects and surface types in a periurban landscape, using multi-spectral and radar data. The optical and microwave sensors have complementary properties to identify urban object and cover mode from spectral responses and micro-textures. [8] propose urban monitoring using multi-temporal SAR and milti-spectral data. They have shown the potential of combining SAR and multi-spectral images to characterize an urban area and improving classification result accuracy. This potential is also demonstrated by [9], [10] and [11]. From [12], certain urban or man-made objects are uniquely detected from radar data (image from RADARSAT-1) and they give additional knowledge to the interpretation of the optical image.

The radar and optical data complementary are shown using GIS functionalities. A raster to vector process is applied on classification results allowing comparisons and combinations from OrbisGIS, a free spatial data infrastructure [13], [14].

2. DATA AND METHODS

This paper analyzes the combined use of a multi-spectral image from SPOT 5, taken in June 2006, and SAR data acquired in 2006 by the airborne RAMSES radar sensor of ONERA. It is an X-band image with an incidence angle of 60° and a sub-metric pixel size in both azimutal and range directions, which allows observing lots of urban objects.

To validate classification results, the Ortho-photo database produced by the French Institute of Geography (IGN) is used. This database is composed of georeferenced aerial photographies taken in 2001, with a 25-30cm of spatial resolution.

The study area is located in the south-east of Toulouse outskirt near Ramonville. This scene is composed of large buildings (collective and industrial buildings), residential houses, natural vegetation, water surface, agricultural fields, road network, bare soil, etc…

From multi-spectral image, a supervised classification with the minimum distance algorithm is used to identify 6 land covers/ land uses: vegetation, grass, residential building, industrial building, road, bare soil. From radar data, we use the classical H/alpha wishart classification [15] leading to 8 different classes. According to the previous desired thematic map in 6 cover/land uses, this result is improved using several polarimetric descriptors in the framework of a decision tree [16].

3. RESULTS

3.1. Classification result from SPOT image

From the SPOT image, a classification algorithm allows to define the land cover / land use in the study area. Compared to the ortho-photo, the cover identification is relatively satisfying (Kappa coefficient of 0,94). The mineral surfaces are correctly separated of vegetative surface. On the other hand, the confusion matrix shows difficulties to separate the road class from the residential houses class and the industrial building class from the residential houses class.

3.2. Classification result from radar image

With the RAMSES processing, the only H/alpha wishart classification leads to many confusion between the different cover/land uses [16]. Indeed, according to a first analysis where the ground truth was produced by the radar image interpretation, many roofs are recognized as trees (more than 30%) or lawns (more than 10%) and the radar shadows are mixed with pixels corresponding to highways. A statistical analysis on several polarimetric descriptors (copolarization and depolarization ratios, anisotropy) permits us to improve this result. However, it was not possible to distinguish most of the highways from radar shadows and confusion between trees and many roofs still exist (around 20%). The overall accuracy was around 77%. In this work, we present a new geocoded result where we take into account that the Wishart law is not more valid in the context of very high spatial resolution and we compute the new confusion matrix using the available ortho-image.

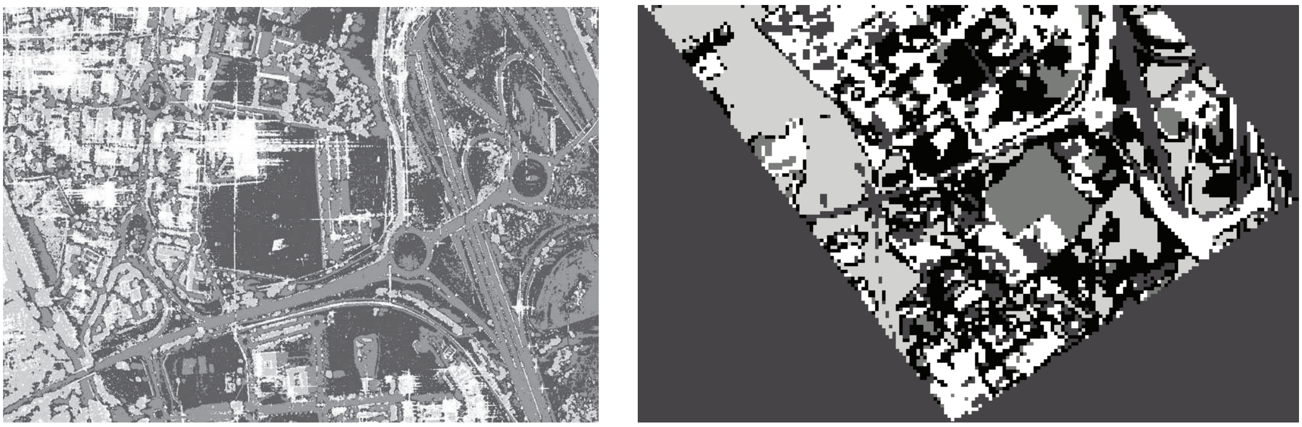

Figure 1: Classified sub-images displayed with four classes: lawns (black), road/highways and radar shadows (dark gray), bare soil (medium grey), trees and small shrubs (light gray), buildings and other man-made objects (white). Left: radar classification result before geocoding. Right: geocoded SPOT classification result on the equivalent area.

3.3. Result comparison from raster to vector process

The spatial resolution of the radar and SPOT images are different: sub-metric and 10m, respectively. To compare the result a raster to vector process is applied in the OrbisGIS platform. Then, superposing the vector files in the GIS, the common / different land cover / land use can be detected and the corresponding surface computed. The most difference appears for the highway class (despite the radar shadows included in this class for the radar classification).
The urban fabric is a very heterogeneous terrain because of the material variety. Study it by spectral methods is not easy and use several ranges of the electromagnetic spectrum appeared like a solution. Indeed, certain confusions in the SPOT classification result may be deleted like the confusion between buildings and road because of the correctly classification of highway from the radar image. In the same way, the confusion between the roofs/buildings and the trees in the radar classification may be cancelled by comparison with the SPOT classification.

4. CONCLUSION

Urbanization has an important impact on natural environment. To determine the artificial surface footprint, the satellite imagery is an excellent source of information because of spatial and temporal resolution (to detect land cover change) and multiplicity of sensors allowing exploring and analyzing all the electromagnetic spectrum ranges. In this study, the combination of the radar and multi-spectral data allows to improve the results of classification from the both images with GIS functionalities to determine more accuracy the land cover and the land use in a periurban district.

5. REFERENCES

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